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(54) Abstract Title

**Amber-free blue glass composition**

(57) A blue soda-lime-silica glass comprises 68 to 75% SiO<sub>2</sub>, 10 to 18% Na<sub>2</sub>O, 5 to 15% CaO, 0 to 10% MgO, 0 to 5% Al<sub>2</sub>O<sub>3</sub>, and 0 to 5% K<sub>2</sub>O, where CaO + MgO is 6 to 15% and Na<sub>2</sub>O + K<sub>2</sub>O is 10 to 20%, and colourants comprising: 0.3 to 0.8 wt. % total iron oxide as Fe<sub>2</sub>O<sub>3</sub> (wherein the ratio of FeO/total Fe as Fe<sub>2</sub>O<sub>3</sub> is 0.34 to 0.62); 0.05 to 0.5 wt. % manganese compound as MnO<sub>2</sub>; 0 to 0.30 wt. % titanium oxide as TiO<sub>2</sub>; and 0 to 0.8 wt. % cerium oxide as CeO<sub>2</sub>. The coloured glass has the following spectral properties at 4.0 mm. thickness: 65 to 81% light transmittance using Illuminant A (LTA) and using Illuminant C has a dominant wavelength of 488 to 494 nanometers with an excitation purity of 4 to 11%. The higher than normal ratio of FeO/total Fe as Fe<sub>2</sub>O<sub>3</sub> is achieved by the addition of a reductant to the glass mix. The reductant may be anthracite coal, blast furnace slag, slag from coal-fired furnace, coke and/or graphite.

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preparation, a group of six different batches is melted in a gas/air fired surface at the same time for 1 hour at 2600°F and each crucible is removed in turn from the furnace and fritted. Fritting the glass involves coating  
5 the inside of the platinum/rhodium crucible by rolling the molten glass around the inside of the crucible and then plunging the crucible into cold water. After removing the crucible from the water and draining, the broken glass particles are removed from the sides of the crucible and  
10 mechanically mixed inside the crucible. All six samples are fritted in like manner and all crucibles are placed back into the furnace for another hour interval at 2600°F and the fritting procedure is repeated. After the second fritting process, the crucibles are returned to the  
15 furnace for 4 hours at 2600°F. Each crucible is removed in turn from the furnace and each molten glass sample is poured into a graphite mold with an inside diameter of 2.5". Each glass is cooled slowly, labeled, and placed into an annealing furnace where the temperature is quickly  
20 raised to 1050°F, held for 2 hours, and then slowly cooled by shutting off the furnace and removing the samples after 14 or more hours. The samples are ground and polished to about 4.0 mm. thickness and subsequently the spectral properties are measured for each sample.

25

All of the examples are made using the above batch only with no cullet (the broken pieces of glass that are added to the batch feed in production). There are two types of cullet that can be added to the batch to produce glass of  
30 the invention: reduced iron blue glass from glass of the

partially or wholly substitute for rouge in the batch up to about 55 pounds Melite per 1000 pounds of sand. MELITE has about 80% of the total iron oxide in the reduced form and thus would require less anthracite coal to generate  
5 similar spectral properties.

The equilibrium reactions that occur in the glass melt which cause a shift in the forms of iron oxide are included by the sodium sulphate used as a refining agent  
10 and carbon used to react with sodium sulphate at lower furnace temperatures. Generally, increasing the quantity of sodium sulphate in the glass tends to shift the iron oxide equilibrium slightly toward oxidizing while increasing carbon concentration in the glass batch shifts  
15 the iron oxide equilibrium toward reducing. Another influence on the iron oxide equilibrium is the peak furnace temperature which when increased will shift the iron oxide slightly toward the reduced state and lowering overall furnace temperature allows the iron oxide to shift  
20 toward the oxidized state.

Melts were made in the laboratory which demonstrate embodiments of this invention using the procedure as follows: 2" inside diameter and dry mixed for 10 minutes  
25 each on a Turbula mixer, dry batch was placed into an 80% platinum/20% rhodium crucible that stands 2" tall and has an inside diameter at the top of 2.5" and is tapered to the base which has an inside diameter of 1.75". An amount of 4.5 ml. of water is added to the dry batch in the  
30 crucible and mixed with a metal spoon. After such

includes rouge, manganese dioxide, and titanium dioxide and cerium oxide, if required.

5 In each of the following tables of examples with the glass composition includes spectral data at 4.0 mm., which is the control thickness. Some tables include thickness other than 4.0 mm. where the most preferred embodiment of the instant invention is with the % LTA greater than or equal to 70.0% and the TSET is less than or equal to  
10 40.0%.

Table III below shows the improvement to infrared absorption by increasing anthracite coal and improvement in ultra violet absorption by increasing manganese  
15 dioxide. Glasses made with the same batch concentrations, but without anthracite coal are green and do not have the level of infrared absorption; this would put those glasses outside the scope of this invention. Glasses made without manganese dioxide develop the amber colour and the  
20 transmittance is significantly lower. Example 1 demonstrates the amber glass generated when manganese dioxide is removed from the batch components. This is compared to Example 3 with manganese added to the glass. Example 1 is not included in glass of this invention and  
25 is used only to illustrate the difference in transmittance and with and without use of manganese oxide.

invention and oxidized iron green glass. The reduced iron blue glass cullet has a redox ratio of about 0.5 to 0.6 while the oxidized iron green glass has a redox ratio of about 0.25. The redox ratio is defined as the ratio of  
5 wt. % FeO /total Fe as wt. % Fe<sub>2</sub>O<sub>3</sub>. For example, if the desired glass of the invention uses 2 pounds of anthracite coal for 1000 pounds of sand, then an additional 1.5 pounds of anthracite coal must be added to the batch when the reduced iron blue glass cullet is added to make 50% of  
10 the batch feed to the furnace for a total of 3.5 pounds of anthracite coal per 1000 pounds of sand. For other cullet levels, the anthracite coal is increased or decreased proportionately. If the oxidized iron green glass cullet is used, more anthracite coal must be added to drive the  
15 oxidized cullet toward the reduced iron blue colour. For example, if the desired glass of the invention uses 2 pounds of anthracite coal for 1000 pounds of sand, then an additional 2.5 pounds of anthracite coal must be added to the batch when the oxidized iron green glass cullet is  
20 added to make 50% of the batch feed to the furnace for a total of 4.5 pounds of anthracite coal per 1000 pounds of sand. When other reductants are used, they must be adjusted proportionately as the anthracite coal in the examples.

25

All laboratory melts made with above procedure use a base composition of 100 grams sand, 32.22 grams soda ash, 8.81 grams limestone, 23.09 grams dolomite, 0.5 to 2.0 grams of sodium sulphate, 0.1 to 0.25 grams of CARBOCITE, 2.64  
30 grams of nepheline syenite, and the remainder of the batch

Table IV demonstrates further improvements in infrared absorption by increasing anthracite coal and in ultra violet absorption when  $\text{MnO}_2$  is increased at constant  $\text{Fe}_2\text{O}_3$ . Generally, as anthracite coal is increased infrared  
5 absorption is increased while as manganese dioxide is increased the ultra violet absorption is increased.

TABLE III

Example	1	2	3	4
Wt. % Fe <sub>2</sub> O <sub>3</sub>	0.5	0.5	0.5	0.5
Wt. % FeO	0.312	0.234	0.293	0.255
Redox Ratio	0.624	0.468	0.586	0.510
Wt. % MnO <sub>2</sub>	0	0.1	0.1	0.4
Wt. % CeO <sub>2</sub>				
Wt. % TiO <sub>2</sub>				
Salt Cake*	10	10	10	10
Anthracite coal*	2.08	1.67	2.08	2.08
Graphite*				
Melite*				
*pounds per 1000 pounds sand				
<b>Spectral Properties @ 4.0 mm. control thickness</b>				
% LTA	67.3	75.46	71.37	73.41
% UV	42.02	57.14	56.35	57.38
% IR	13.62	21.48	15.14	18.79
% TSET	36.1	46.41	40.63	44.14
Dominant wavelength	549.8	490.3	493.5	490.1
% Excitation Purity	7.7	6.	6.2	7.2
<b>Most Preferred Embodiment of Invention with Spectral Properties @ indicated thickness</b>				
Thickness in mm.		5.4	4.2	4.8
% LTA		70.7	70.6	70.67
% UV		51.3	55.4	53.75
% IR		13.4	14.1	13.96
% TSET		39.6	39.6	39.97
Dominant Wavelength		490.2	493.5	490
% Excitation Purity		8	6.4	8.6

Table V demonstrates that slag from coal burning facilities, for example, MELITE<sup>(RM)</sup> processed by Calumite Corporation can be used as a partial or complete  
5 substitute for rouge to generate products within the scope of the invention. MELITE<sup>(RM)</sup> contains iron oxide where approximately 80% of the iron oxide is in the reduced form while about 98% of the iron is rouge is in the oxidized form. Less anthracite coal is required to reduce the  
10 glass batch using MELITE<sup>(RM)</sup> than batch with rouge.

TABLE IV

Example	5	6	7	8	9
Wt. % $\text{Fe}_2\text{O}_3$	0.5	0.5	0.5	0.5	0.5
Wt. % $\text{FeO}$	0.2	0.249	0.198	0.241	0.276
Redox Ratio	0.400	0.498	0.396	0.482	0.552
Wt. % $\text{MnO}_2$	0.05	0.05	0.45	0.45	0.45
Wt. % $\text{CeO}_2$					
Wt. % $\text{TiO}_2$					
Salt Cake*	10	10	10	10	10
Anthracite coal*	1.44	1.67	1.67	2	2.22
Graphite*					
Melite*					
* pounds per 1000 pounds sand					
Spectral Properties @ 4.0 mm. control thickness					
% LTA	76.96	74.56	75.36	74	72.32
% UV	57.94	59.99	50.56	54.85	55.79
% IR	26.03	19.51	26.33	20.41	16.63
% TSET	49.61	45.12	48.54	45.01	42.08
Dominant wavelength	490.1	488.8	493.4	490.8	491.3
% Excitation Purity	5.7	7.8	4.7	6.6	7.1
Most Preferred Embodiment of Invention with Spectral Properties @ indicated thickness					
Thickness in mm.				5	4.4
% LTA				70.27	70.7
% UV				50.16	53.9
% IR				14.35	14.4
% TSET				39.81	40
Dominant Wavelength				490.7	491.3
% Excitation Purity				8.2	7.8

Table VI shows that graphite can be used to substitute for anthracite coal in glass of the invention. Other carbonaceous materials could substitute for anthracite coal or graphite where the ratio of carbon content would  
5 be compared to that of graphite or anthracite coal.

TABLE V

Example	10	11	12	13
Wt. % Fe <sub>2</sub> O <sub>3</sub>	0.5	0.5	0.5	0.5
Wt. % FeO	0.208	0.236	0.255	0.303
Redox Ratio	0.416	0.472	0.510	0.606
Wt. % MnO <sub>2</sub>	0.1	0.1	0.1	0.1
Wt. % CeO <sub>2</sub>				
Wt. % TiO <sub>2</sub>				
Salt Cake*	10.5	10.5	10.5	10.5
Anthracite coal*	1.05	1.16	1.31	1.5
Graphite*				
Melite*	34.2	34.2	34.2	34.2
*pounds per 1000 pounds sand				
Spectral Properties @ 4.0 mm. control thickness				
% LTA	74.89	73.64	72.93	69.85
% UV	54.37	55.76	57.78	55.23
% IR	24.85	21.07	18.82	14.32
% TSET	47.86	45.34	43.91	39.57
Dominant wavelength	490.9	489.9	489.4	492.3
% Excitation Purity	5.8	7	7.7	7.2
Most Preferred Embodiment of Invention with Spectral Properties @ indicated thickness				
Thickness in mm.				3.9
% LTA				70.3
% UV				55.7
% IR				14.9
% TSET				40
Dominant Wavelength				492.3
% Excitation Purity				7

Table VII indicates the impact of salt cake in glass of the invention. Salt cake is used to remove gaseous inclusions, from the glass in the furnace by growing bubbles larger, bubbles rising to the surface and then  
5 breaking open at the melt surface and releasing the accumulated gases. Increasing salt cake in the batch tends to oxidize the glass and requires increasing anthracite coal. Excess use of salt cake is discouraged because the excess salt cake releases  $SO_x$  emissions.  
10 Other sulphates can substitute for salt cake in glass of the invention.

TABLE VI

Example	14	15	16	17	18	19
Wt. % $\text{Fe}_2\text{O}_3$	0.55	0.55	0.55	0.65	0.65	0.65
Wt. % $\text{FeO}$	0.207	0.226	0.249	0.27	0.271	0.295
Redox Ratio	0.376	0.411	0.453	0.415	0.417	0.454
Wt. % $\text{MnO}_2$	0.1	0.1	0.1	0.1	0.1	0.1
Wt. % $\text{CeO}_2$						
Wt. % $\text{TiO}_2$						
Salt Cake*	10	10	10	10	10	10
Anthracite coal*						
Graphite*	1.17	1.25	1.34	1.18	1.25	1.33
Melite*						
*pounds per 1000 pounds sand						
Spectral Properties @ 4.0 mm. control thickness						
% LTA	75.87	74.44	73.61	72.15	71.76	71.12
% UV	55.82	56.7	57.56	52.13	51.94	53.71
% IR	25.01	22.32	19.44	17.27	17.19	14.96
% TSET	48.47	46.59	44.58	42.47	42.24	40.87
Dominant wavelength	490.6	489.8	489.2	490.1	490.1	489.4
% Excitation Purity	5.7	6.5	7.5	7.4	7.5	8.5
Most Preferred Embodiment of Invention with Spectral Properties @ indicated thickness						
Thickness in mm.			4.9		4.4	4.2
% LTA			70.3		70.1	70.5
% UV			53.6		50	53.8
% IR			14		15	13.9
% TSET			39.9		39.9	39.9
Dominant Wavelength			489.1		490	489.4
% Excitation Purity			9		8.2	8.9

Table VIII indicates the wide range of  $\text{Fe}_2\text{O}_3$  that can be used to demonstrate the instant invention. Products that follow the teachings of the instant invention can vary in thickness from 1.5 to 8.0 mm. and can be used in  
5 architectural as well as automotive applications. Automotive applications include laminated products such as windshields.

TABLE VII

Example	20	21	22	23
Wt. % Fe <sub>2</sub> O <sub>3</sub>	0.5	0.5	0.5	0.5
Wt. % FeO	0.257	0.291	0.204	0.24
Redox Ratio	0.514	0.582	0.408	0.480
Wt. % MnO <sub>2</sub>	0.1	0.45	0.1	0.45
Wt. % CeO <sub>2</sub>				
Wt. % TiO <sub>2</sub>				
Salt Cake*	10	10	15	15
Anthracite coal*	1.9	2.11	1.82	2.22
Graphite*				
Melite*				
*pounds per 1000 pounds sand				
Spectral Properties @ 4.0 mm. control thickness				
% LTA	73.89	71.18	76.46	74.19
% UV	58.57	54.25	56.91	54.93
% IR	18.66	15.34	25.44	20.57
% TSET	44.25	40.69	48.99	45.19
Dominant wavelength	489.2	492.5	490.4	490.9
% Excitation Purity	7.8	6.7	5.7	6.5
Most Preferred Embodiment of Invention with Spectral Properties @ indicated thickness				
Thickness in mm.	5	4.2	6	5
% LTA	70.16	70.3	70.05	70.05
% UV	54.34	53.5	48.75	50.27
% IR	12.87	14.3	13.94	14.49
% TSET	39.23	39.6	39.49	39.98
Dominant Wavelength	489.1	492.5	490.2	490.8
% Excitation Purity	9.6	6.9	8.5	8

itself does not sufficiently increase the ultra violet absorption alone but as manganese dioxide increases, the ultra violet absorption again increases.

TABLE VIII

Example	24	25	26	27	28	28
Wt. % Fe <sub>2</sub> O <sub>3</sub>	0.3	0.35	0.45	0.6	0.65	0.7
Wt. % FeO	0.152	0.179	0.213	0.334	0.321	0.352
Redox Ratio	0.507	0.511	0.473	0.557	0.494	0.503
Wt. % MnO <sub>2</sub>	0.1	0.1	0.1	0.1	0.1	0.1
Wt. % CeO <sub>2</sub>						
Wt. % TiO <sub>2</sub>						
Salt Cake*	10	10	10	10	10	10
Anthracite coal*	1.81	1.82	1.81	2.01	1.82	1.82
Graphite*						
Melite*						
*pounds per 1000 pounds sand						
Spectral Properties @ 4.0 mm. control thickness						
% LTA	80.34	78.75	76.65	69.26	69.01	67.83
% UV	68.86	66.43	61.33	54.3	51.57	50.85
% IR	34.96	29.66	24.13	11.97	12.87	10.87
% TSET	56.35	52.77	48.55	38.08	38.63	36.97
Dominant wavelength	488.9	488.7	489.6	490.7	489.2	489.2
% Excitation Purity	4.9	5.7	6.2	8.6	9.4	10.1
Most Preferred Embodiment of Invention with Spectral Properties @ indicated thickness						
Thickness in mm.		7.2	6	3.7	3.5	4.2
% LTA		70.1	70.32	70.7	70	70.4
% UV		56.8	53.97	55.8	53.7	53.6
% IR		13	12.91	13.8	14.1	14
% TSET		39.5	39.27	39.7	39.8	40
Dominant Wavelength		488.4	489.5	490.7	489.3	489.2
% Excitation Purity		10.1	9.1	7.9	9.1	8.9

Table IX indicates the improvement in ultra violet absorption that cerium oxide makes. Cerium oxide by

components manganese dioxide and cerium oxide to be 0.45 wt. % or greater.

Table X shows the improvement in ultra violet absorption  
5 made by the addition of titanium dioxide and that the dominant wavelength increases toward a green colour. Titanium dioxide is capped at 0.3 wt. %. There is a trace amount of titanium dioxide in the sands that adds about 0.01 wt. %  $\text{TiO}_2$  to the glass composition.

TABLE IX

Example	30	31	32	33	34	35	36	37	38
Wt. % $\text{Fe}_2\text{O}_3$	0.5	0.5	0.7	0.8	0.5	0.5	0.5	0.5	0.5
Wt. % $\text{FeO}$	0.286	0.25	0.309	0.357	0.275	0.283	0.25	0.251	0.203
Redox Ratio	0.572	0.500	0.441	0.446	0.550	0.566	0.500	0.502	0.406
Wt. % $\text{MnO}_2$	0.06	0.12	0.4	0.4	0.45	0.05	0.45	0.05	0.45
Wt. % $\text{CeO}_2$	0.5	0.5	0.5	0.5	0.2	0.4	0.4	0.8	0.8
Wt. % $\text{TiO}_2$									
Salt Cake*	10.5	10.5	10.5	10.5	10	10	10	10	10
Anthracite coal*	2.1	2.1	2.1	2.1	2.22	2	2.22	2	2.23
Graphite*									
Melite*									
*pounds per 1000 pounds sand									
Special Properties @ 4.0 mm. control thickness									
% LTA	72.21	74.58	68.32	65.22	72.46	72.3	72.77	73.68	75.58
% UV	47.46	48.91	38.04	35.32	50.32	48.48	45.47	45.74	41.37
% IR	15.81	19.47	13.78	10.56	16.77	16.02	19.31	19.22	25.58
% TSET	41.37	44.75	38.12	34.83	42.17	41.49	43.49	44.11	47.97
Dominant Wavelength	491.2	489.5	492.3	492.3	490.6	491.6	491.5	489.4	493.9
% Excitation Purity	7.1	7.3	7.3	8.2	7.4	7	6.5	7.5	4.6

Lowering the ultra violet transmittance below 50% at  
5 4.0 mm. control thickness requires greater than 0.2 wt. %  
 $\text{MnO}_2$  and greater than 0.2 wt. %  $\text{CeO}_2$  or the total of the

Table XI indicates the ultraviolet absorption improvements when cerium oxide and titanium dioxide are used in combination. Lowering the ultra violet transmittance below 50% at 4.0 mm. control thickness requires greater  
5 than 0.05 wt. %  $\text{MnO}_2$ , greater than 0.2 wt. %  $\text{CeO}_2$  and greater than 0.1 wt. %  $\text{TiO}_2$  or the total of the components manganese dioxide, cerium oxide and titanium dioxide to be 0.55 wt. % or greater.

TABLE X

Example	39	40	41	42	43
Wt. % Fe <sub>2</sub> O <sub>3</sub>	0.5	0.5	0.5	0.5	0.5
Wt. % FeO	0.239	0.238	0.261	0.26	0.253
Redox Ratio	0.478	0.476	0.522	0.520	0.506
Wt. % MnO <sub>2</sub>	0.2	0.2	0.2	0.2	0.4
Wt. % CeO <sub>2</sub>					
Wt. % TiO <sub>2</sub>	Tramp	0.05	0.1	0.2	0.3
Salt Cake*	10	10	10	10	10.5
Anthracite coal*	1.9	1.9	1.9	1.9	2.1
Graphite*					
Melite*					
* pounds per 1000 pounds sand					
Spectral Properties @ 4.0 mm. control thickness					
% LTA	75.22	74.68	73.82	73.6	73.35
% UV	59.38	57.34	57.52	55.12	50.08
% IR	20.77	20.79	18.25	18.33	19.13
% TSET	46.05	45.7	43.84	43.61	43.58
Dominant wavelength	489.4	490	490.4	491.5	494
% Excitation Purity	7.1	6.8	7.1	6.5	5.5
Most Preferred Embodiment of Invention with Spectral Properties @ indicated thickness					
Thickness in mm.	5.5	5.1	5	4.8	4.8
% LTA	70.1	70.5	70.07	70.55	70.25
% UV	53.4	52.5	53.02	51.22	45.78
% IR	12.6	14.1	12.52	13.57	14.26
% TSET	39	40	38.8	39.42	39.28
Dominant Wavelength	489.2	489.9	490.3	491.4	493.9
% Excitation Purity	9.6	8.6	8.8	7.8	6.5

coal and magnesium dioxide shifts the iron oxide equilibrium towards the reduced form of iron (FeO). Manganese oxide also prevents excessive reduction of sulphate to form iron sulphide that is amber in colour and  
5 will decrease the transmittance of the glass.

As any person skilled in the art will recognize from the previous description and from the figures and claims, modifications and changes can be made to the preferred  
10 embodiment of the invention without departing from the scope of the invention as defined in the following claims.

The disclosures of United States patent application number 10/074,626 from which this application claims priority, and  
15 of the abstract which accompanies this application are incorporated herein by reference.

TABLE XI

Example	44	45	46	47	48	49	50	51
Wt. % Fe <sub>2</sub> O <sub>3</sub>	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
Wt. % FeO	0.263	0.246	0.255	0.254	0.25	0.261	0.231	0.255
Redox Ratio	0.526	0.492	0.510	0.508	0.500	0.522	0.462	0.450
Wt. % MnO <sub>2</sub>	0.12	0.05	0.15	0.2	0.2	0.2	0.2	0.2
Wt. % CeO <sub>2</sub>	0.5	0.25	0.25	0.025	0.05	0.1	0.2	0.3
Wt. % TiO <sub>2</sub>	0.1	0.25	0.25	0.025	0.05	0.1	0.2	0.1
Salt Cake*	10.5	10.5	10	10	10	10	10	10
Anthracite coal*	2.1	1.75	1.91	1.9	1.9	1.9	1.9	1.9
*pounds per 1000 pounds sand								
Spectral Properties @ 4.0 mm. control thickness								
% LTA	73.47	74.01	73.04	73.78	74.25	73.4	74.71	75.2
% UV	46.4	47.82	46.06	57.3	56.01	53.05	47.83	48.2
% IR	18.03	19.8	18.7996	18.96	19.41	18.25	21.68	22.47
% TSET	43.22	44.4	43.27	44.32	44.72	43.52	45.71	46.47
Dominant Wavelength	490.6	491.4	492.2	489.5	489.7	490.5	492.3	491.2
% Excitation Purity	7	6.2	6.1	7.4	7.2	7.1	5.6	5.9
Most Preferred Embodiment of Invention with Spectral Properties @ indicated thickness								
Thickness in mm.	4.8	5	4.8	5	5	4.8	5.2	5.5
% LTA	70.39	70.28	69.89	70.01	70.57	70.31	70.4	70.1
% UV	43.08	43.39	42.3	53.06	51.8	49.52	42.5	41.9
% IR	13.3	13.83	13.96	13.11	13.5	13.5	14.3	13.9
% TSET	39.08	39.23	39.01	39.25	39.65	39.36	39.4	39.2
Dominant Wavelength	490.6	491.4	492.2	489.4	489.7	490.4	492.3	491.1
% Excitation Purity	8.3	7.7	7.3	10.9	8.9	8.4	7.2	8

As can be seen from the examples above, the glass in accordance with the present invention provides for high transmittance, an improved infrared light absorption and an ultra violet absorption. Further, the use of anthracite

titanium oxide as  $\text{TiO}_2$  is in the range of 0.05 to 0.3 wt %.

7. The coloured glass of Claim 1, wherein the cerium oxide as  $\text{CeO}_2$  is in the range of 0.1 to 0.5 wt %.

5

8. The coloured glass of Claim 1, wherein the base has a composition by weight of the coloured glass comprising:

68 to 75%  $\text{SiO}_2$ ;  
10 10 to 18%  $\text{Na}_2\text{O}$ ;  
5 to 15%  $\text{CaO}$ ;  
0 to 10%  $\text{MgO}$ ;  
0 to 5%  $\text{Al}_2\text{O}_3$ ; and  
0 to 5%  $\text{K}_2\text{O}$ ,  
15 wherein the total amount of  $\text{CaO}$  and  $\text{MgO}$  is 6 to 15% and the total amount of  $\text{Na}_2\text{O}$  and  $\text{K}_2\text{O}$  is 10 to 20%.

9. A method of manufacturing an amber free blue  
20 glass, the method comprising:

mixing and melting a pre-determined amount of raw material, wherein the raw materials has the following composition:

Sand	1000 lbs;
Soda Ash	290 to 350 lbs;
Limestone	70 to 90 lbs;
Dolomite	215 to 260 lbs;
Salt cake	5 to 15 lbs;

CLAIMS

1. A coloured glass for use in a motor vehicle having a base and a colourant, the colourant having a  
5 composition by weight of the coloured glass consisting:

0.3 to 0.8 wt. % of iron oxide as  $\text{Fe}_2\text{O}_3$ , wherein the redox ratio of FeO and total iron as  $\text{Fe}_2\text{O}_3$  is in the range of 0.34 to 0.62;

0.05 to 0.50 wt. % of manganese oxide as  $\text{MnO}_2$ ;

10 0.0 to 0.3 wt. % of titanium oxide as  $\text{TiO}_2$ ;

up to 0.8 wt. % of cerium oxide as  $\text{CeO}_2$ , wherein the coloured glass at 4 mm. control thickness has a light transmittance using illuminant A between 65.0% and 81.0% and a dominant wavelength using illuminant C is in a range  
15 of 488 to 494 nanometers.

2. The coloured glass of Claim 1, wherein the coloured glass at 4mm. thickness has an excitation purity in the range of 4% to 11%.

20

3. The coloured glass of Claim 1, wherein the dominant wavelength in the range of 488 to 491 nanometers.

4. The coloured glass of Claim 1, wherein the total  
25 iron as  $\text{Fe}_2\text{O}_3$  is in the range of 0.4 to 0.6 wt %.

5. The coloured glass of Claim 1, wherein the manganese oxide as  $\text{MnO}_2$  is in the range of 0.05 to 0.2 wt%.

30 6. The coloured glass of Claim 1, wherein the

present in the range of 1.0 to 2.3 pounds per 1000 pounds of sand.

11. The method of claim 9, wherein the reductant is  
5 selected from a group consisting of anthracite coal, blast furnace slag, slag from coal fired furnace, coke, graphite or mixtures thereof.

12. The method of Claim 9, wherein the coloured  
10 glass at 4mm. thickness has an excitation purity in the range of 4% to 11%.

13. The method of Claim 9, wherein the dominant  
wavelength in the range of 488 to 491 nanometers.  
15

14. The method of Claim 9, wherein the total iron as  $\text{Fe}_2\text{O}_3$  is in the range of 0.4 to 0.60 wt %.

15. The method of Claim 9, wherein the manganese  
20 oxide as  $\text{MnO}_2$  is in the range of 0.05 to 0.2 wt %.

16. The method of Claim 9, wherein the titanium  
oxide as  $\text{TiO}_2$  is in the range of 0.05 to 0.3 wt %.

17. The method of Claim 9, wherein the cerium oxide  
25 as  $\text{CeO}_2$  is in the range of 0.1 to 0.5 wt %.

18. The method of Claim 9, wherein the base has a  
composition by weight of the coloured glass by weight of  
30 the coloured glass comprising: